Electronic Search Patterns

Locating the ELT Signal

- Route or parallel track to pick up the signal
- If no SARSAT hits or definitive Last Known Point (LKP):
  - 4,000 to 10,000 AGL
  - Large track spacing (start at 60 nm, then do halves)
- Once signal is located, DF the signal

Direction Finder (DF)

- A direction finder compares signal strengths from two antenna patterns to let the user know:
  - When you are “centered” on a signal
    - headed directly towards OR away from from the signal source
  - Which direction to turn when not centered
  - Similar to an ADF needle, but only points left or right, hence the term “left-right homing”

L-Tronics DF

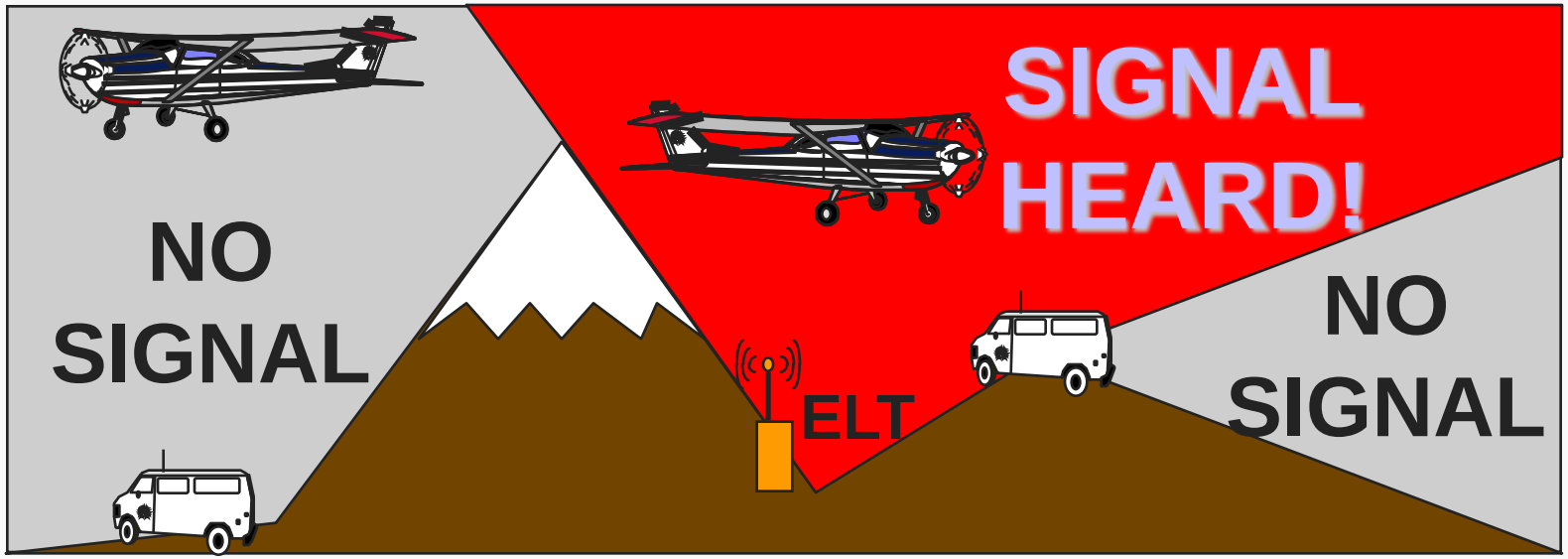
- Normal: Alarm toggle in ‘up’ position
- DF: toggle is ‘down’

Step 1: Acquire the Signal

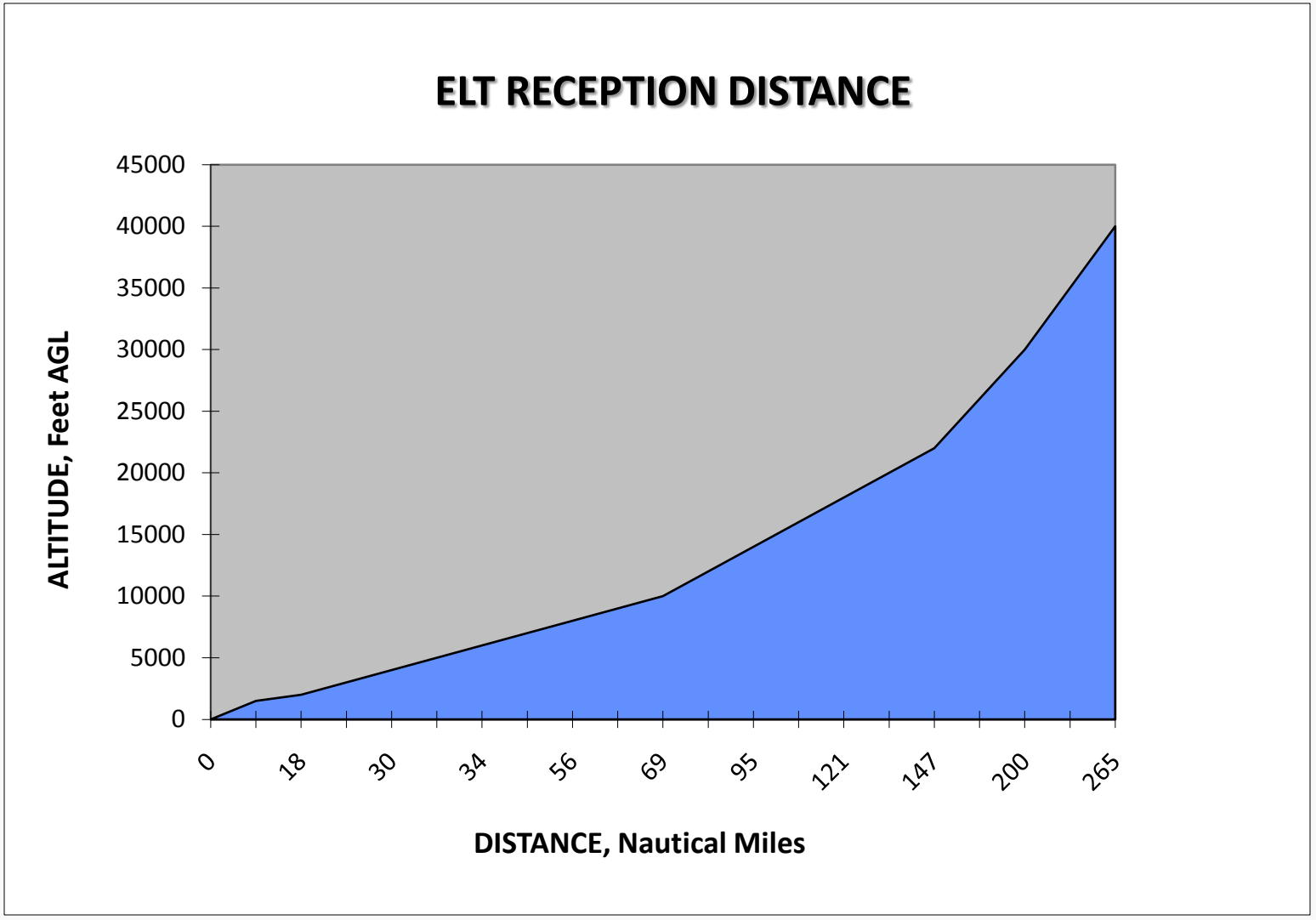
- To hear the signal you can use your L-Tronics receiver or one of your comm radios
- To acquire with a comm radio, turn the squelch OFF
  (pull out the volume knob out or flip the appropriate switch)
  - The static you hear may be annoying, but it will allow you to hear the signal at the earliest possible time
  - Allows for a weak or distant signal to be heard
- Proceed at a reasonable altitude to the SARSAT composite hit, or to the point designated by your incident commander

Beginning The Search: Altitude Selection

- Higher altitudes allow for reception of the ELT signal at greater distances
- ELTs transmit on 121.5 MHz and 243.0 MHz, both of which limit reception to “line of sight”
- Terrain will block ELT signals
- HIGHER is therefore usually BETTER to acquire a signal
- Medium altitude is generally better for *searching* (after signal heard)
  - 3,000 to 5,000 AGL



Search Altitude Selection



Step 2: Track (DF) the Signal

- There are many different ways to DF an ELT signal:
  - Left-Right DF Homing (L-Tronics DF)
  - Wing Shadow Method
  - Aural Search
  - Metered Search
  - Combinations of the above techniques

Wing Shadowing

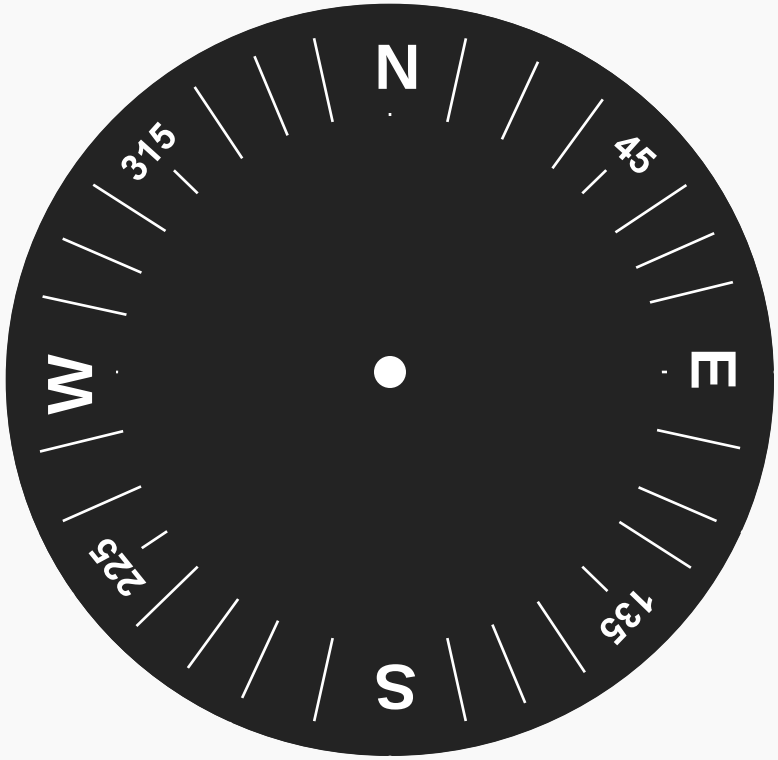
- By flying the airplane in a circle, at some point the wing will block the ELT signal to the receiver antenna
  - This causes an audible decrease in volume, called a “null”
- Almost any VHF-AM aircraft communications radio may be used with this method

Wing Shadowing: Antennas

- To properly use the Wing Shadowing method, you MUST know where the antenna for the radio you are using is installed & located on the aircraft
- Communications radio antennas are usually, but not always, located above the wings
  - Can be above the fuselage, in the tail, etc.
- L-Tronics Aircraft DF antennas may be above or below the aircraft
  - <u>Below</u> the aircraft is the preferred installation

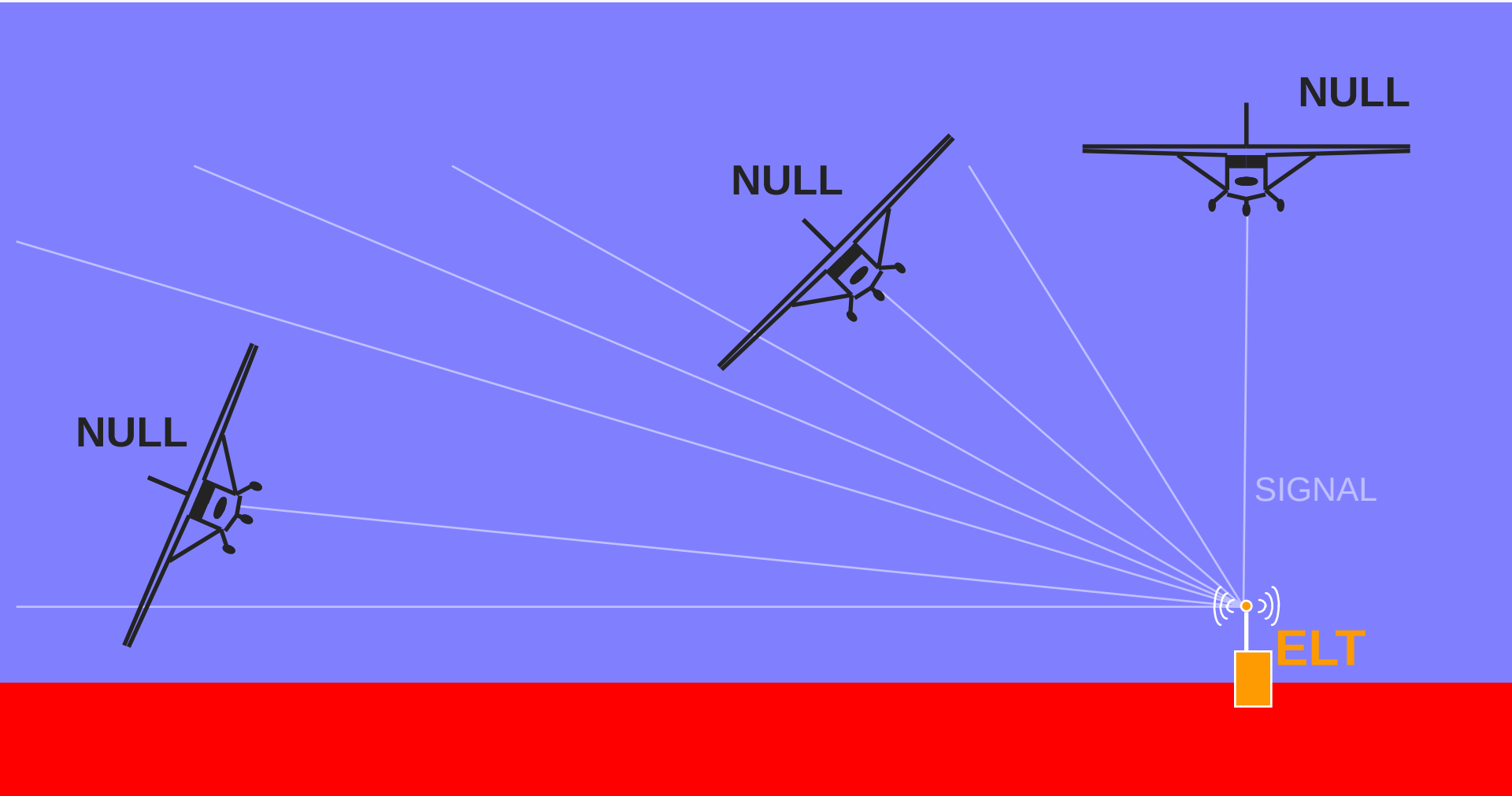
How To DF by Wing Shadowing

- Fly a constant bank angle 360° turn
- the audio will “null,”
- or get significantly quieter,
- when your wing blocks the antenna’s reception of the ELT signal



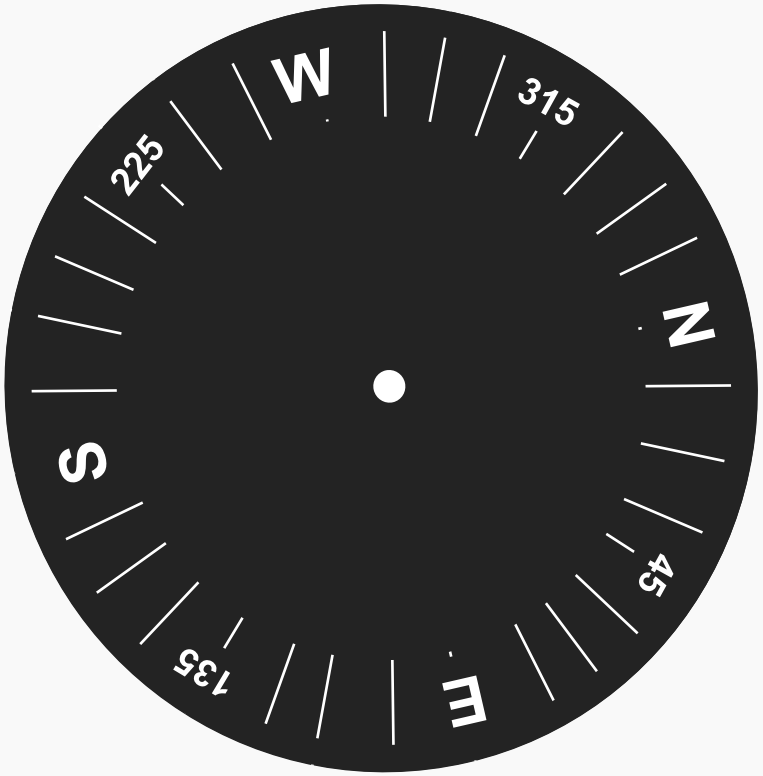
Wing Shadowing: Signal Blocking

For Antennas Above the Wings



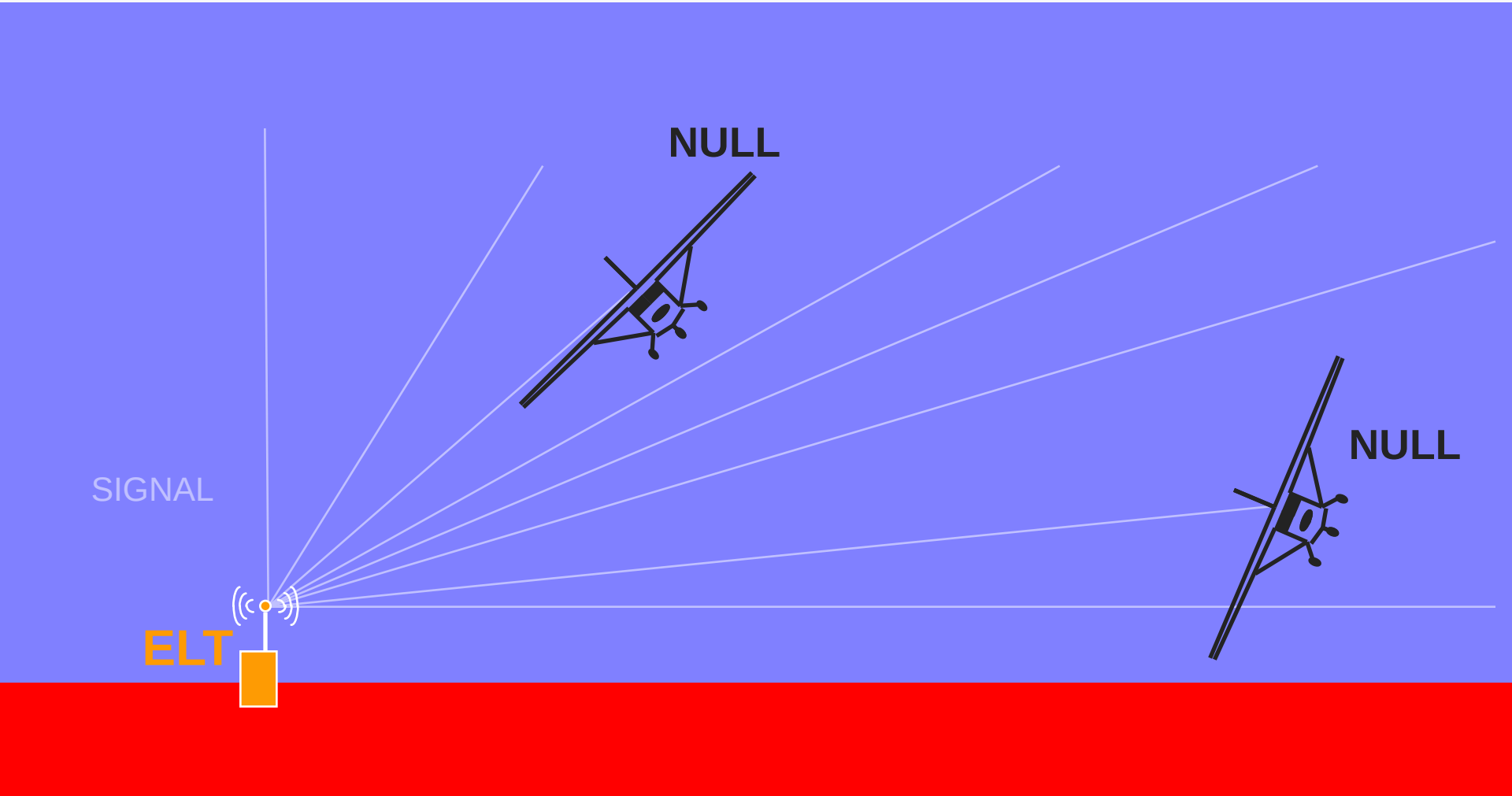
Wing Shadowing:
Antennas Above the Wing

- Turn in a circle until you hear the null (significant decrease in volume)
- The ELT is 90º to your LEFT
- SUBTRACT 90º from your heading



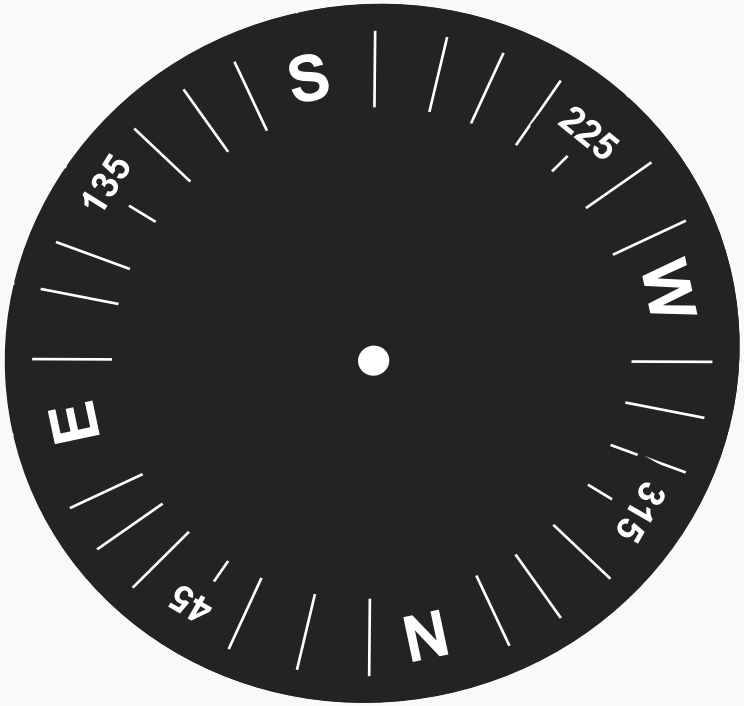
Wing Shadowing: Signal Blocking

For Antennas Below the Wings



Wing Shadowing:
Antennas Below the Wing

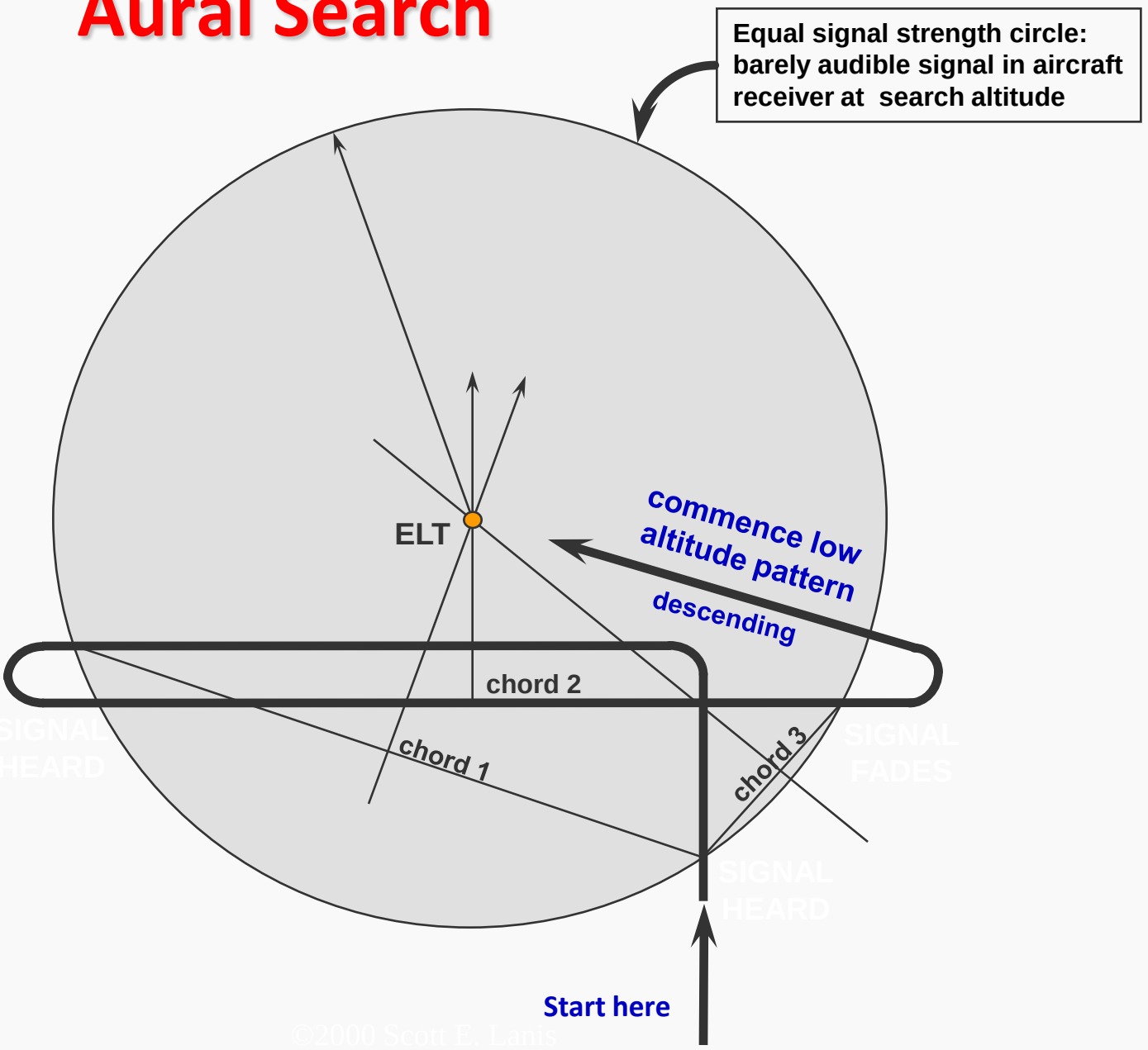
- Turn in a circle until you hear the null (significant decrease in volume)
- The ELT is 90º to your RIGHT: ADD 90º to your heading



Aural (Hearing) Search Method

- This is based on the assumption that the area of equal beacon signal strength is circular: do NOT adjust volume during this search; you will need it to determine equal levels of signal
- Begin by plotting your position as soon as you receive the ELT signal
- Fly that course for a short distance, then turn 90º left or right and proceed until the signal fades
- Turn around (180º) and mark where the signal fades on the other side of the circle
- Plot chord lines similar to that of the diagram
- Bisect the chord lines at a perpendicular
- Plot a course to the location where the perpendicular lines intersect: this should be the location of the target!

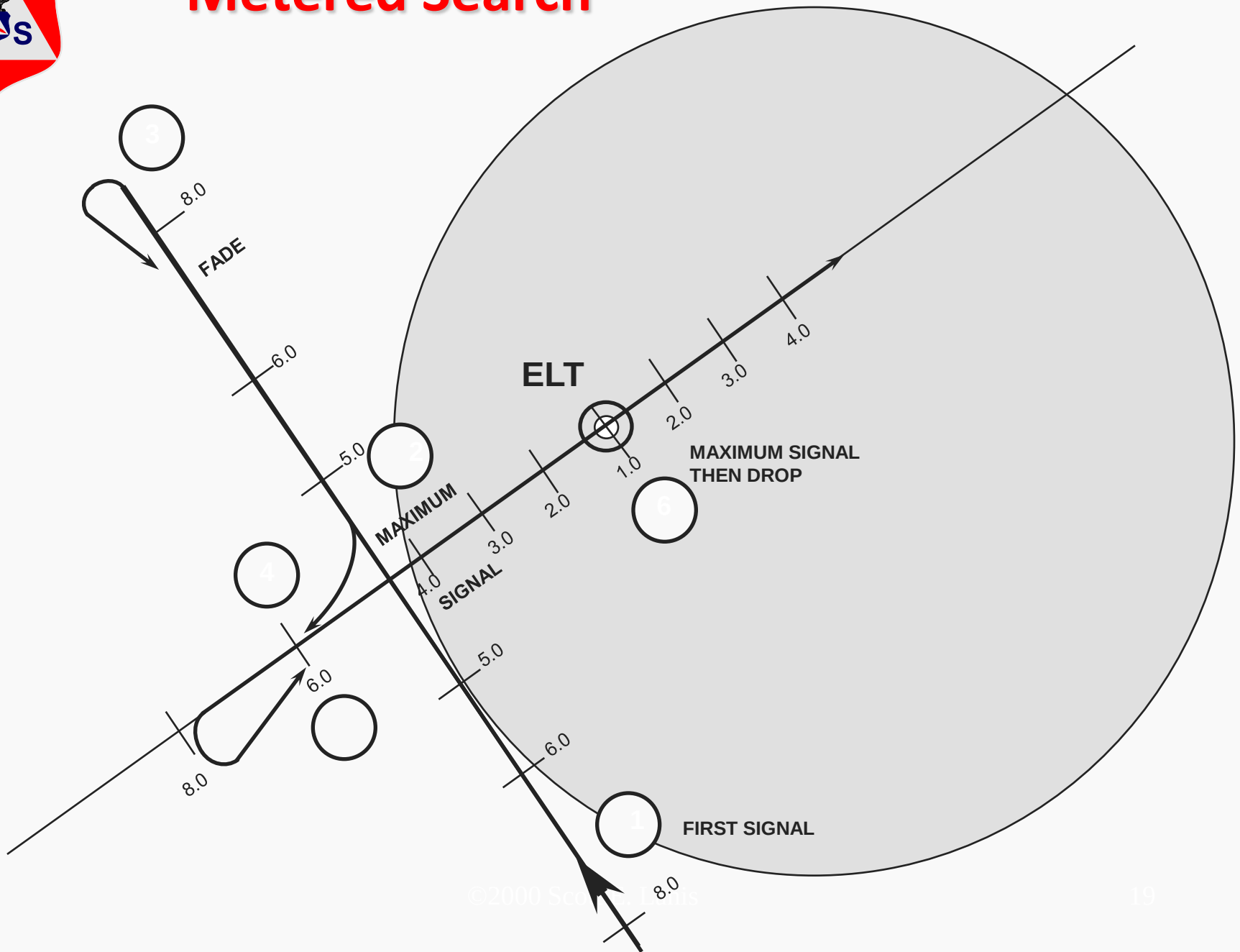
Aural Search



Metered Search (Build & Fade) Method

- This search requires a signal strength meter (like that on the L-Tronics DF units-if the DF portion of the unit is inoperative you can still use this type of search as long as RECeive is OK.
- Note your signal strength when beginning the search.
- Fly a straight line until the signal gets lower, then increases to your original level.
- Turn 180º and return to the lowest level of signal, then turn 90º left or right.
- You should now be headed directly towards or away from the transmitter.
- If the signal increases in strength, you are headed directly for the ELT.
- If the signal decreases in strength, turn 180º

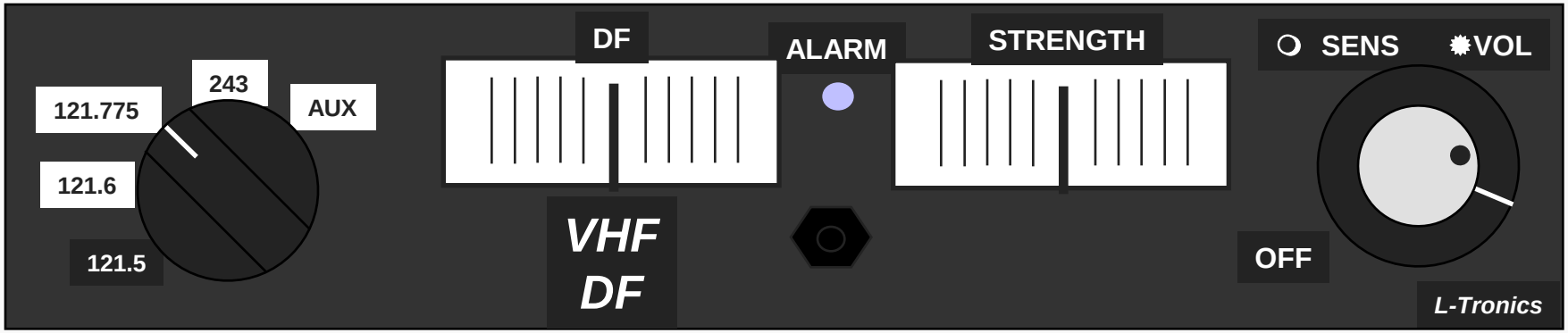
Metered Search



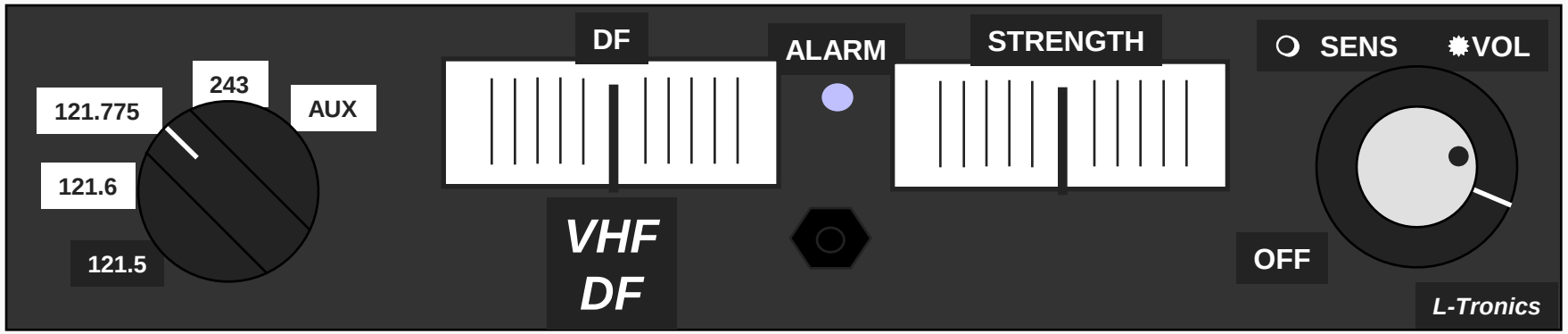
Left-Right DF Homing

- Most CAP corporate aircraft have L-Tronics LA-Series Left-Right Homing DF units
- These units operate virtually the same, but there are two major varieties:
  - Single Meter Models
  - Dual Meter Models

L-Tronics DF

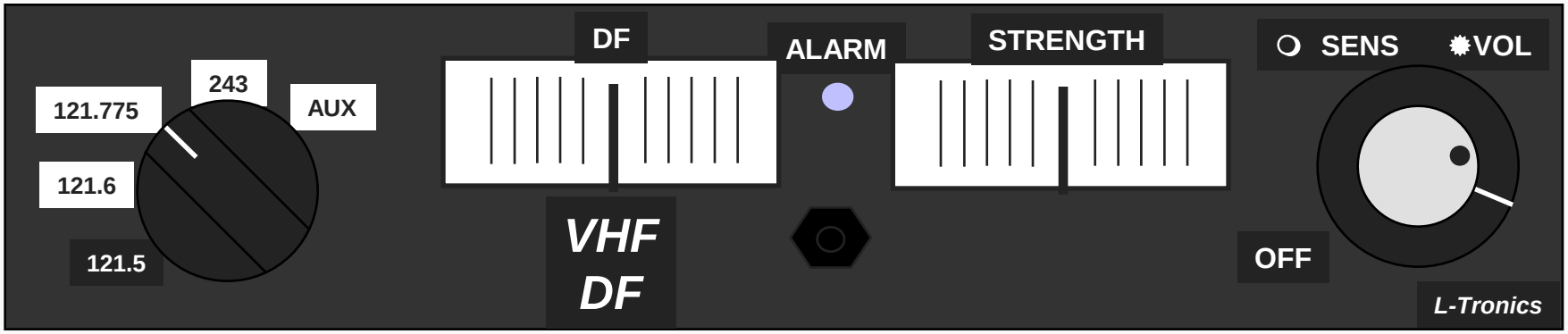


Frequency Switch



- Selects frequency to be used
- Use 121.5 MHz for actual ELTs/EPIRBs
- 243.0 MHz may also be used for all actual electronic searches
- Use 121.775 MHz for training
- Refer to owners manual for use of the “AUX” position

Volume & Sensitivity



- Volume controls the audio level to the speaker or headsets
- Sensitivity controls the *amount of signal* that enters into the DF unit
  - It is critical that the proper amount of signal enters the DF: half-scale, or the middle, is an optimum starting place
- As the signal gets stronger, reduce SENSITIVITY, *not* volume
  - The DF will be unreliable as too much signal is received, so you must cut out part of it by reducing the sensitivity
  - More than three-quarters scale is too much

DF Settings

- **MISSIONS**
  - Select 121.5 (or 121.775 for training missions)
  - Ensure Alarm Toggle Off
  - Turn Sensitivity to Maximum (Full Clockwise)
  - Turn Volume to About Mid-Scale
  - DF Should Stay About Centered
  - Strength Meter Will Move Up-Scale to Right

- **NON-MISSION FLIGHTS**
  - Select 121.5
  - Turn Alarm Toggle On
  - Turn Sensitivity To Maximum

PRE-FLIGHT FUNCTIONAL CHECK

- Just as you pre-flight the rest of the aircraft, you should preflight your DF when going on an ELT electronic search mission
- These procedures are covered in the *Mission Aircrew Reference Text*.

SIX STEPS

- Use these 6 steps for locating ELTs and EPIRBs with L-Tronics LA- series airborne DF equipment
- Use the *full* procedure every time for the best results
  - RECeive
  - HALF
  - DF
  - TURN
  - CHECK
  - SHOOT
- Each of these steps will be described in detail in the slides to follow

Step 1: RECeive

- Once you have started to receive the ELT or EPIRB signal on the proper frequency
- If you have a single-meter unit, turn the mode selector to RECeive and turn the volume to a comfortable level
- If you have a dual meter unit, refer to the STRENGTH window (no need to change modes)

RECeive Mode/STRENGTH Window

- In receive mode or in the strength window, the unit measures signal strength
  - Needle to the left means low; to the right means high
- Values are *relative* depending on the sensitivity you have selected
- You may still be able to use the strength meter even if the DF is not functioning perfectly
  - It is possible to locate an ELT using only the Receive Mode
  - Utilize Aural Search/Metered Search methods to accomplish
  - If the unit isn't completely operable, try wing shadowing using one of the aircraft's communications radios and use the DF unit's strength meter as a backup using the aural/metered methods

Step 2: HALF

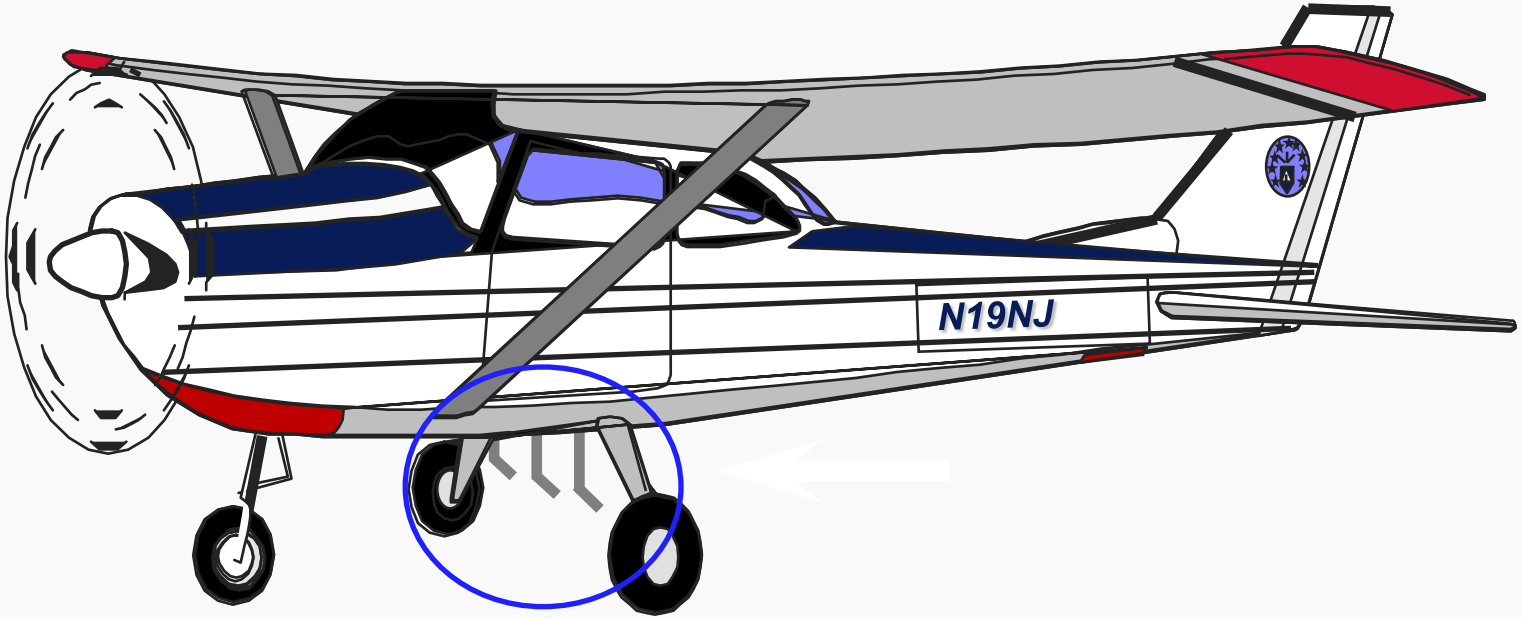
- Now that the unit is in RECeive mode and you have a good signal, turn the Sensitivity Knob to HALF SCALE
  - This is in the center of the window
- If you are flying with a dual-meter unit, turn the Sensitivity Knob so the needle reads HALF SCALE in the STRENGTH window
- A half-scale strength reading will prevent too much signal (over sense) from entering the unit and will provide you with a good starting point
- It is also the optimum for the DF homing antennas

Step 3: DF

- For single-meter units, turn the mode selector knob to DF
- In DF mode, you can think of the needle as always pointing Direct to the Flipping target.
- For dual-meter models, simply refer to the DF window (no need to change modes)

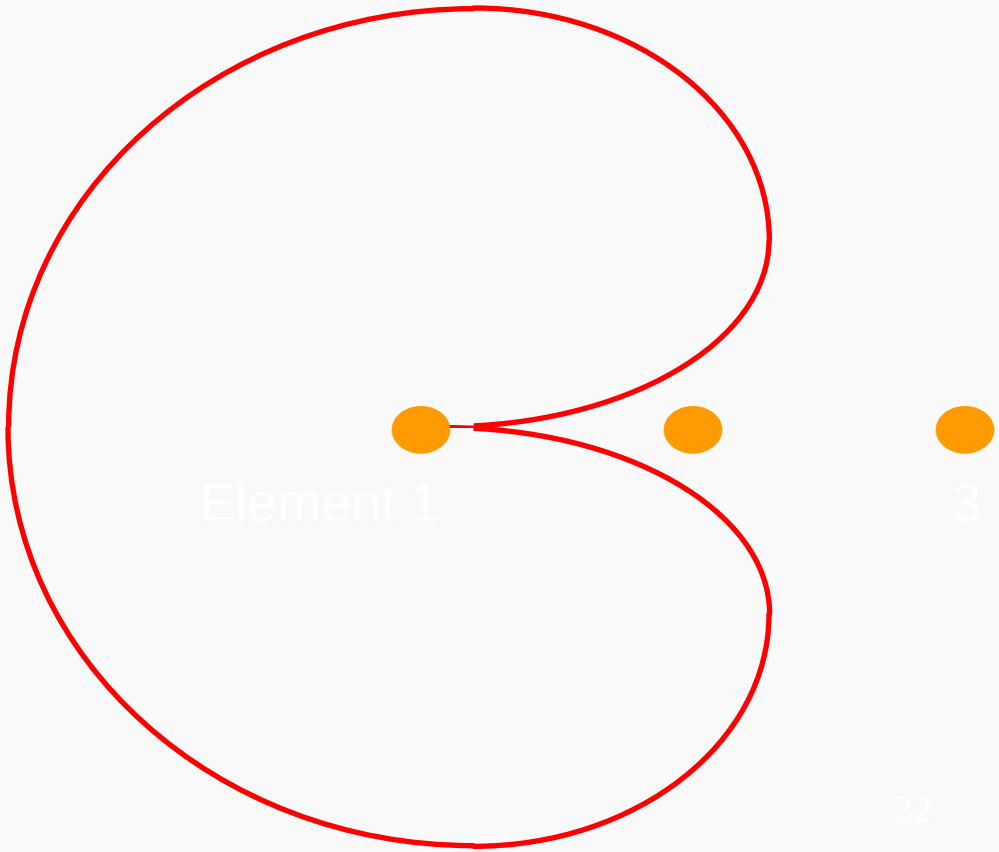
DF Antenna

- The aircraft DF unit has a 2 or 3 “element” antenna
  - Commonly, we might call this two or three antennas
  - It just means there are two or three rods!
- This antenna setup is directional
  - One element actually receives the signal
  - The other elements (rods) *reflect* the signal away from the first rod



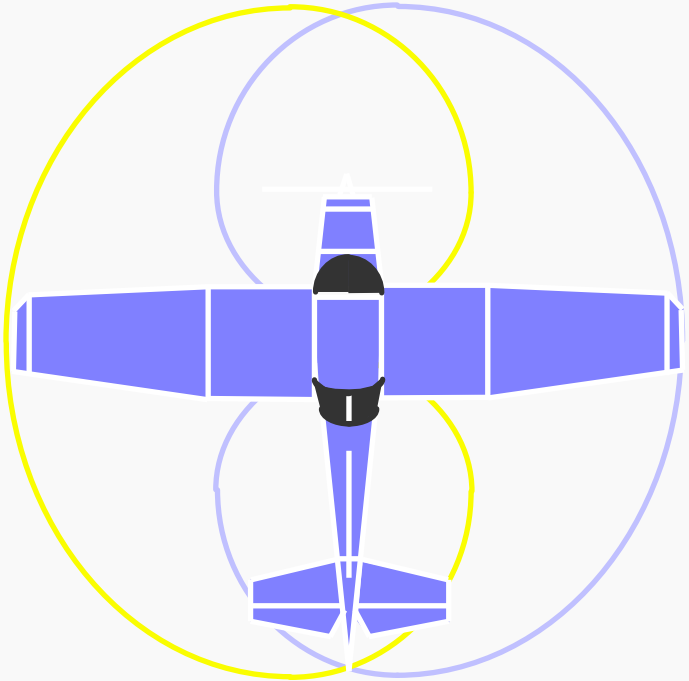
Antenna Reception Pattern

- When viewed from the bottom, an antenna setup like the one pictured on the previous slide produces a reception pattern like the one shown here
  - This pattern is called “carotid,” which means “heart-shaped”
- The pattern is the same even if the antennas are mounted above the wing



Direction Finding Mode/Window

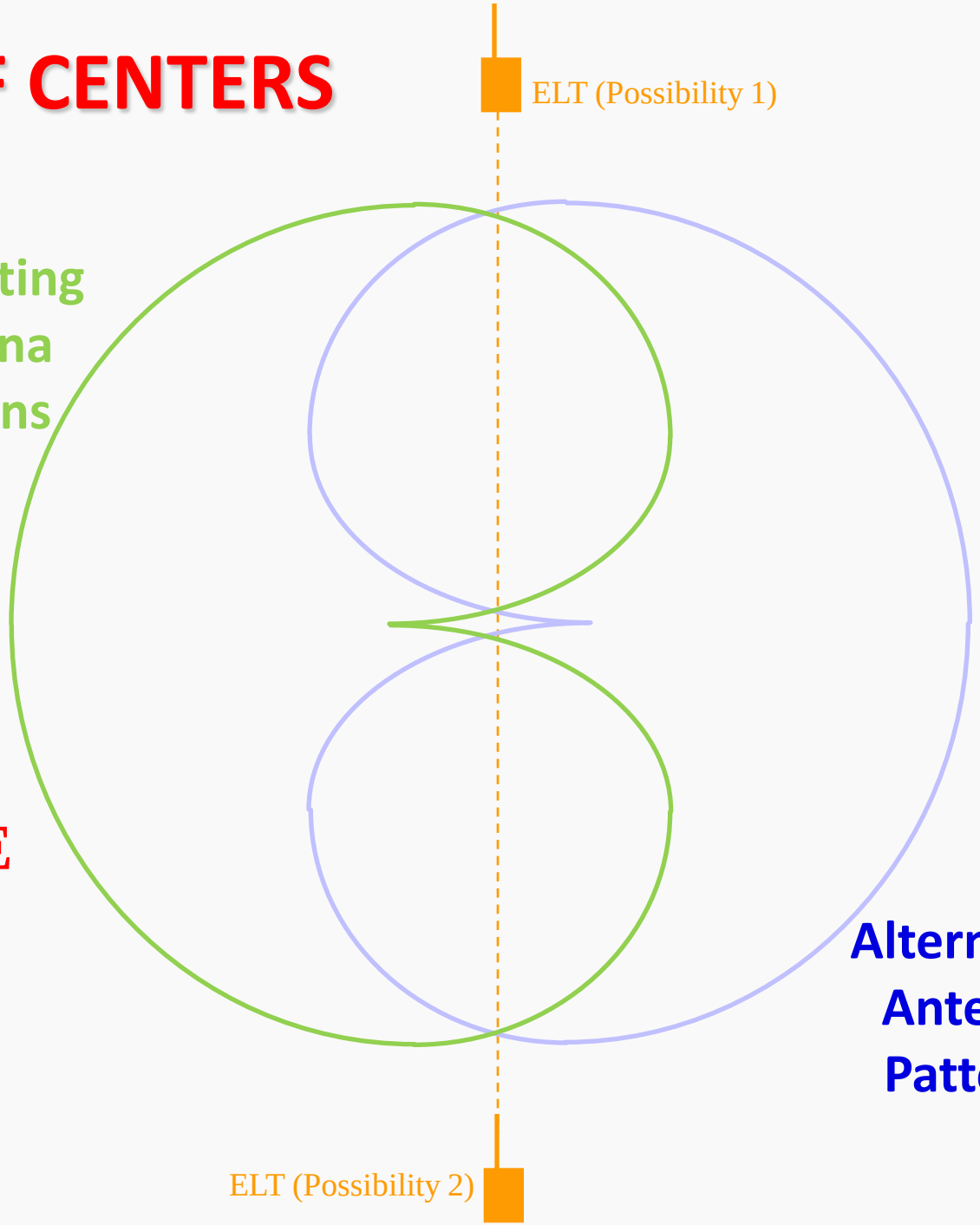
- The DF mode rapidly alternates the receiving and reflecting antenna elements
  - It chooses one element as the receiver and the other two as the reflectors, then switches to the other set
- This produces a carotid pattern each time the unit switches
  - one is shown in blue, the other in yellow
- By comparing the two patterns, the unit will determine when they are equal
- When they're equal, the needle centers!
- When the needle is centered, the target is either directly ahead or behind you!



Step 4: TURN

- Turn at least one FULL circle, noting where the DF needle centers
- Under ideal conditions, the needle will center twice
  - When facing directly at the source of the signal
  - When facing 180º away from the target
- You will solve this problem (called ambiguity) in the next step

DF CENTERS



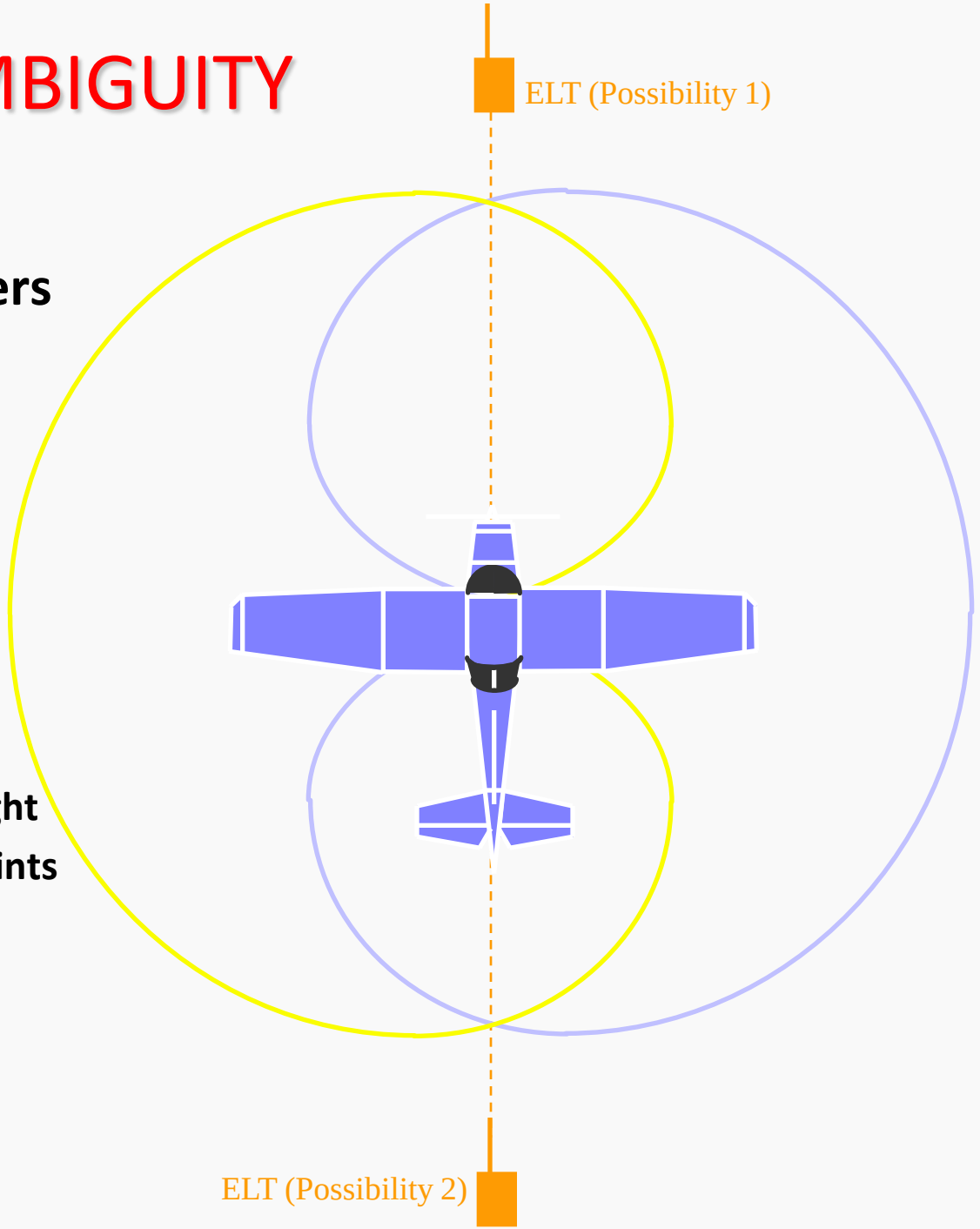
WHEN THE PATTERNS ARE EQUAL, THE DF NEEDLE CENTERS!

Step 5: CHECK

- Use Turn to Tell
- Remembering that in DF mode the needle always points Direct to the Flipping target
- When you have the needle centered, turn left or right
  - If you turn left and the needle goes left, the ELT is 180º from your present heading
  - If you turn left and the needle turns right, the ELT is dead ahead

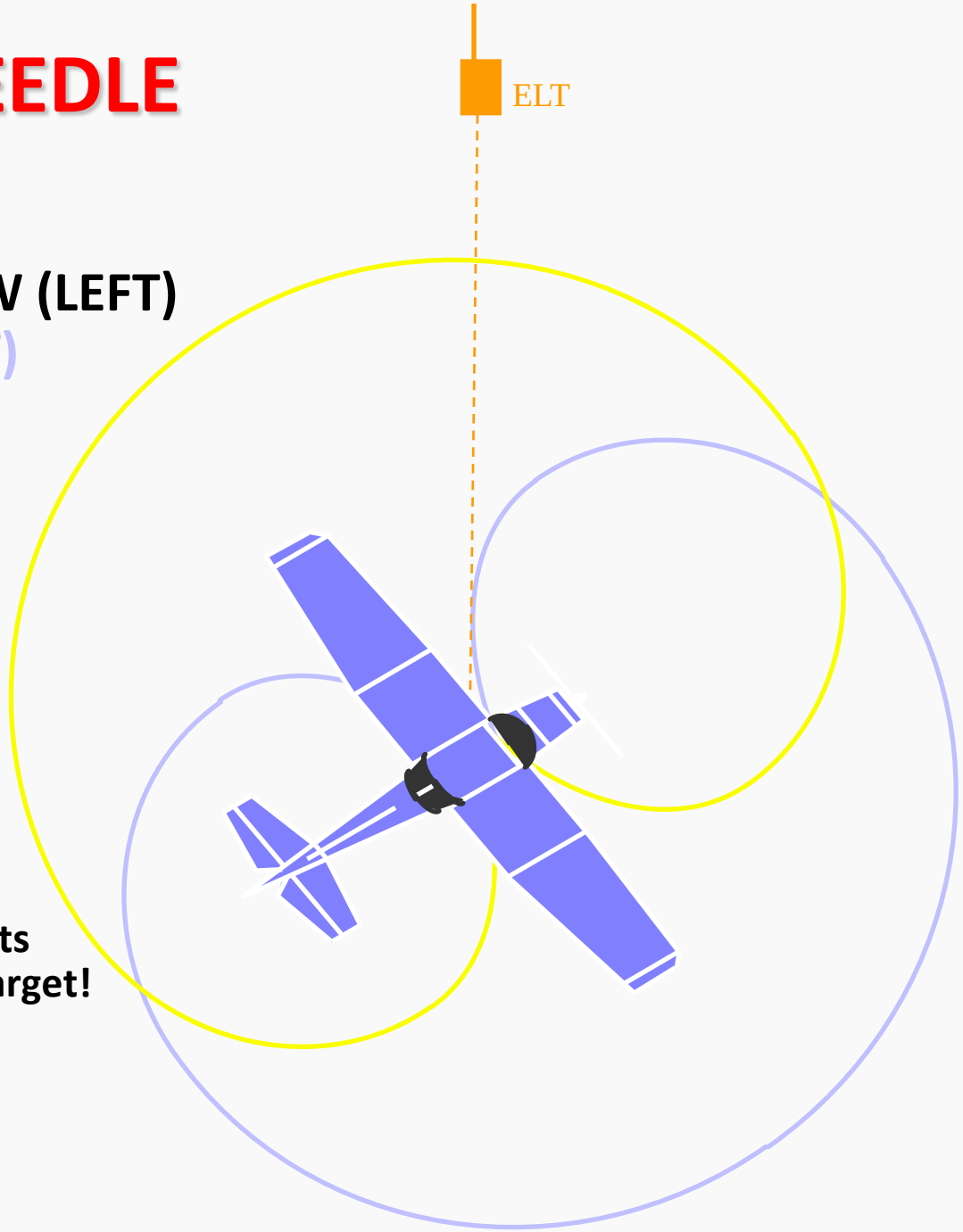
AMBIGUITY

- **When Needle Centers**
  - **ELT is Directly Ahead or Behind**
- **This situation is called “ambiguity”**
- **To Solve ambiguity:**
- **Use Turn to Tell**
  - **Make a turn left or right**
  - **The needle always points Direct to the Flipping Target (DF!)**



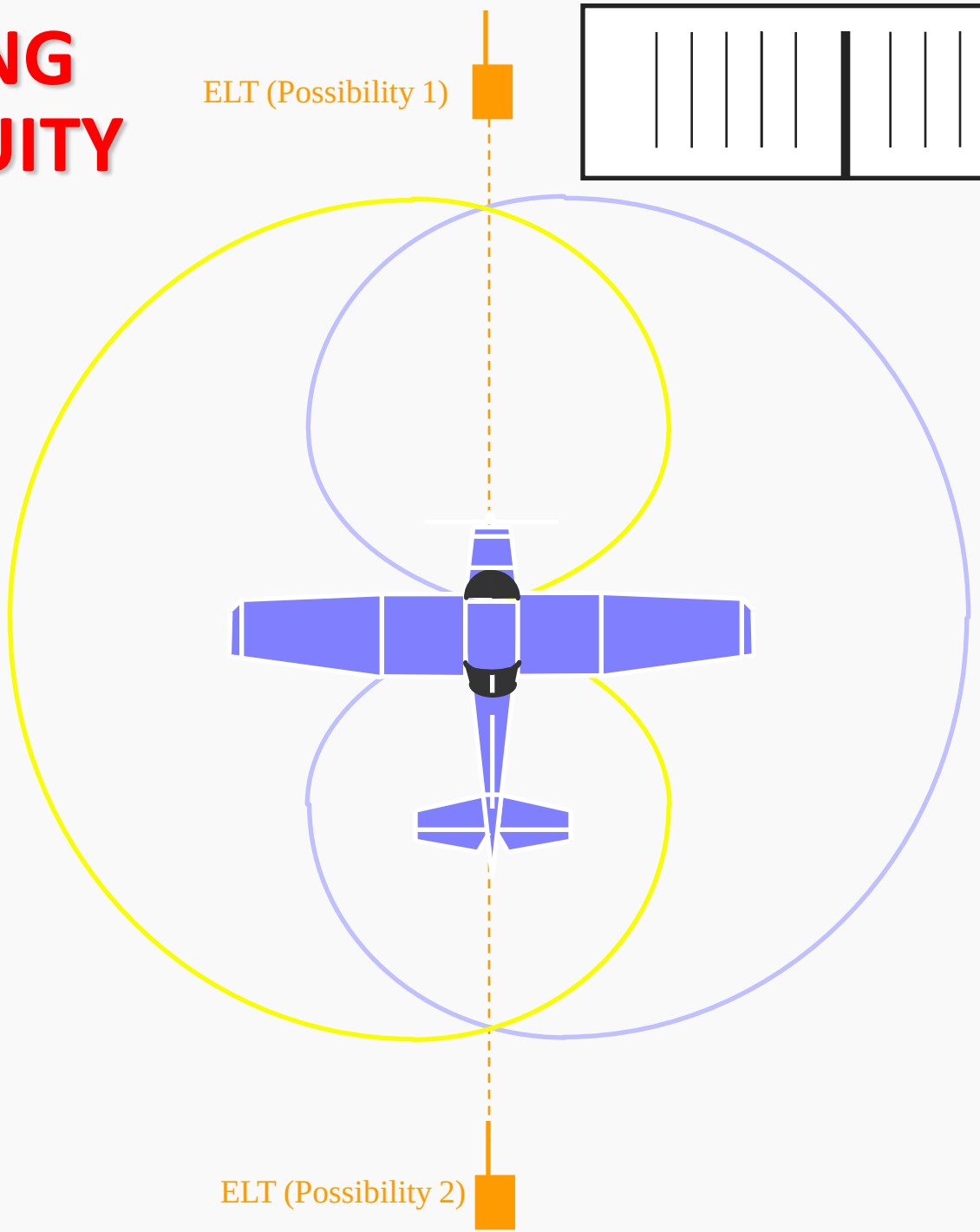
DF NEEDLE

- Compare the YELLOW (LEFT) and the BLUE (RIGHT) antenna patterns
- In this case, the LEFT pattern is stronger than the RIGHT
- In DF mode, the needle would then point LEFT
  - The needle always points Direct to the Flipping Target!



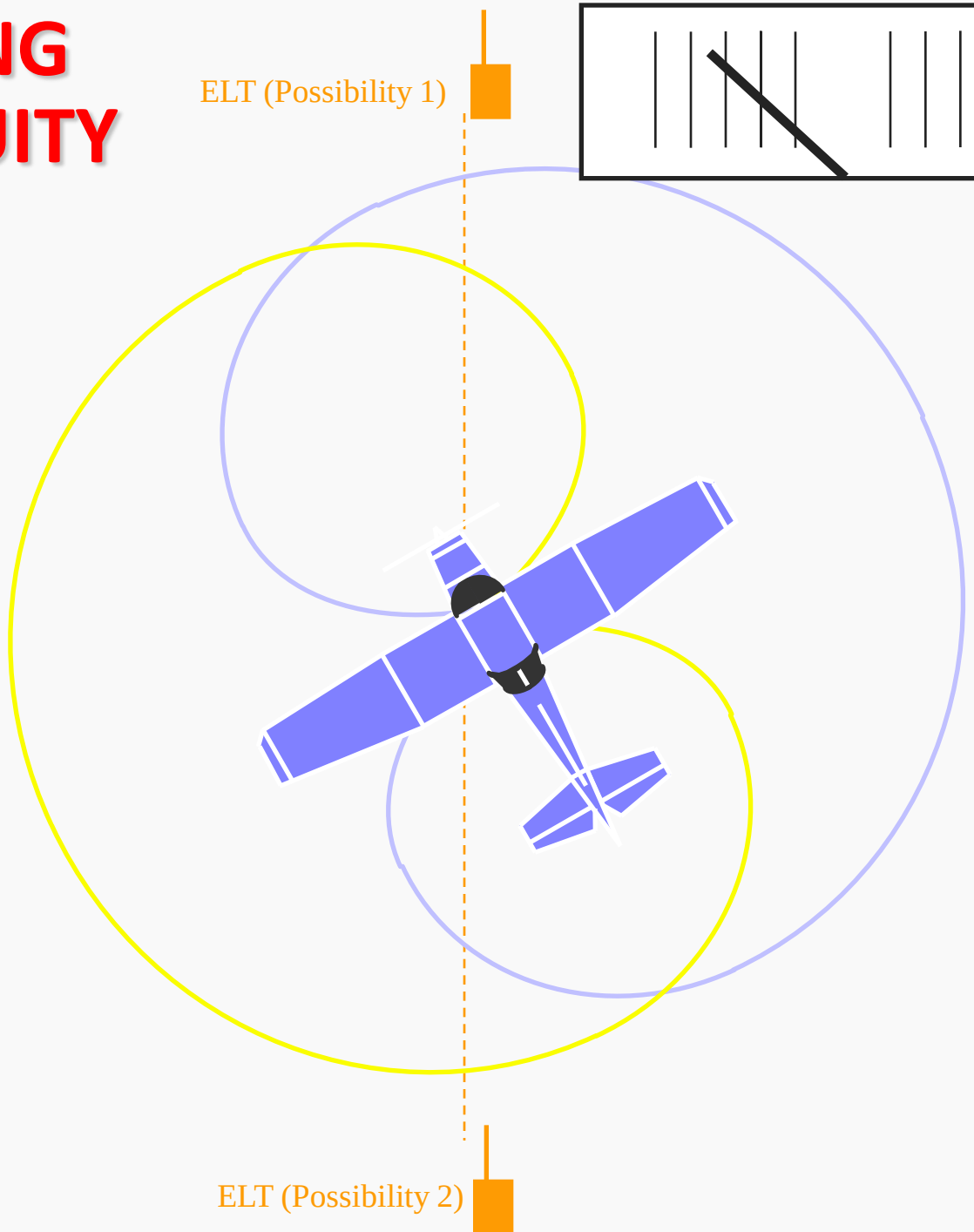
SOLVING AMBIGUITY

- Actual ELT position is unknown to user
- Make a small turn left or right
  - As a teaching reminder, “Use a TURN to TELL”

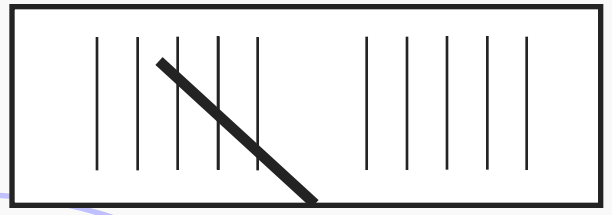


SOLVING AMBIGUITY

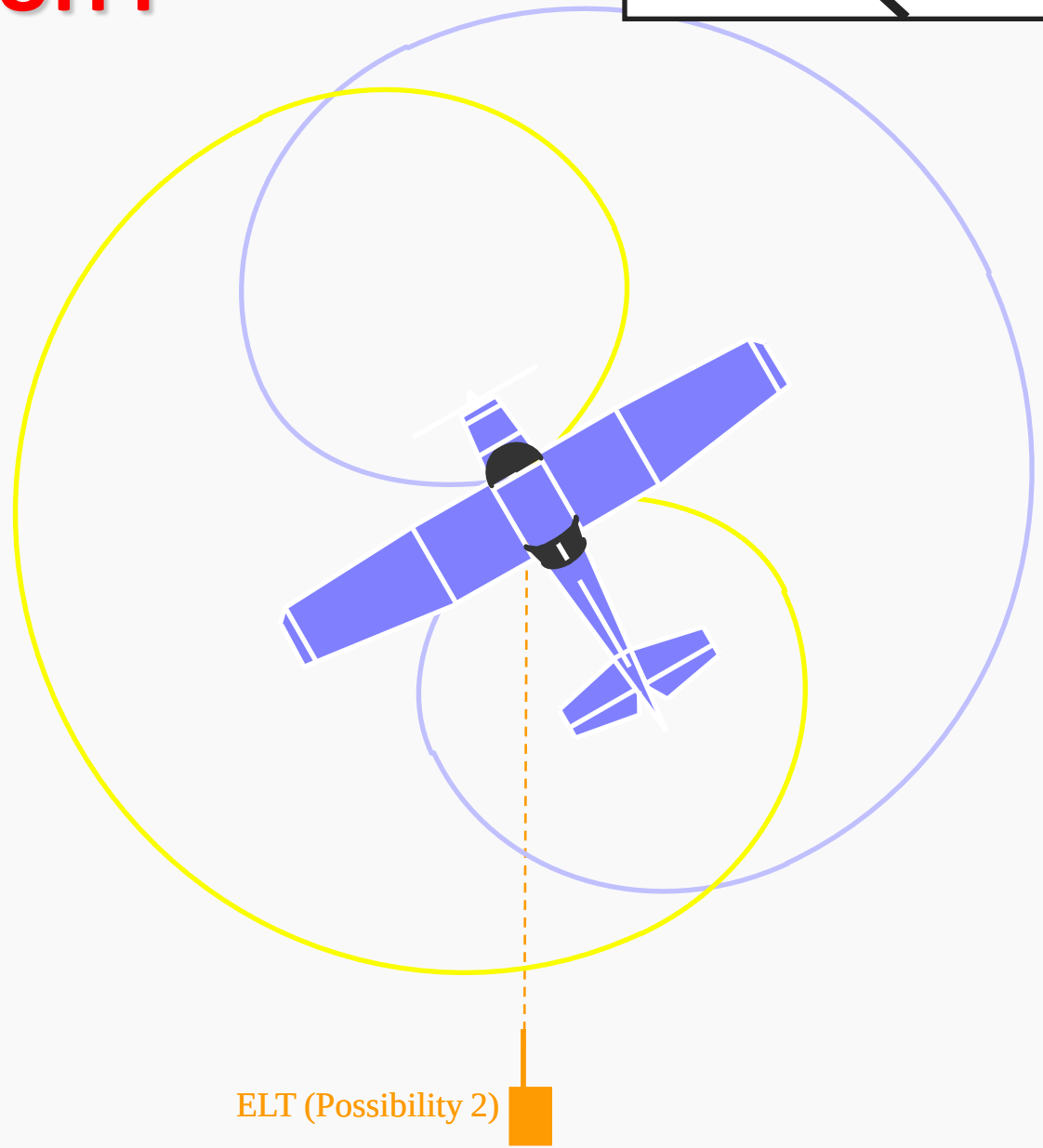
- Actual ELT position is unknown to user
- Make a small turn left or right
  - As a teaching reminder, “Use a TURN to TELL”
- Example:
  - TURN LEFT
  - needle goes left



SOLVING AMBIGUITY

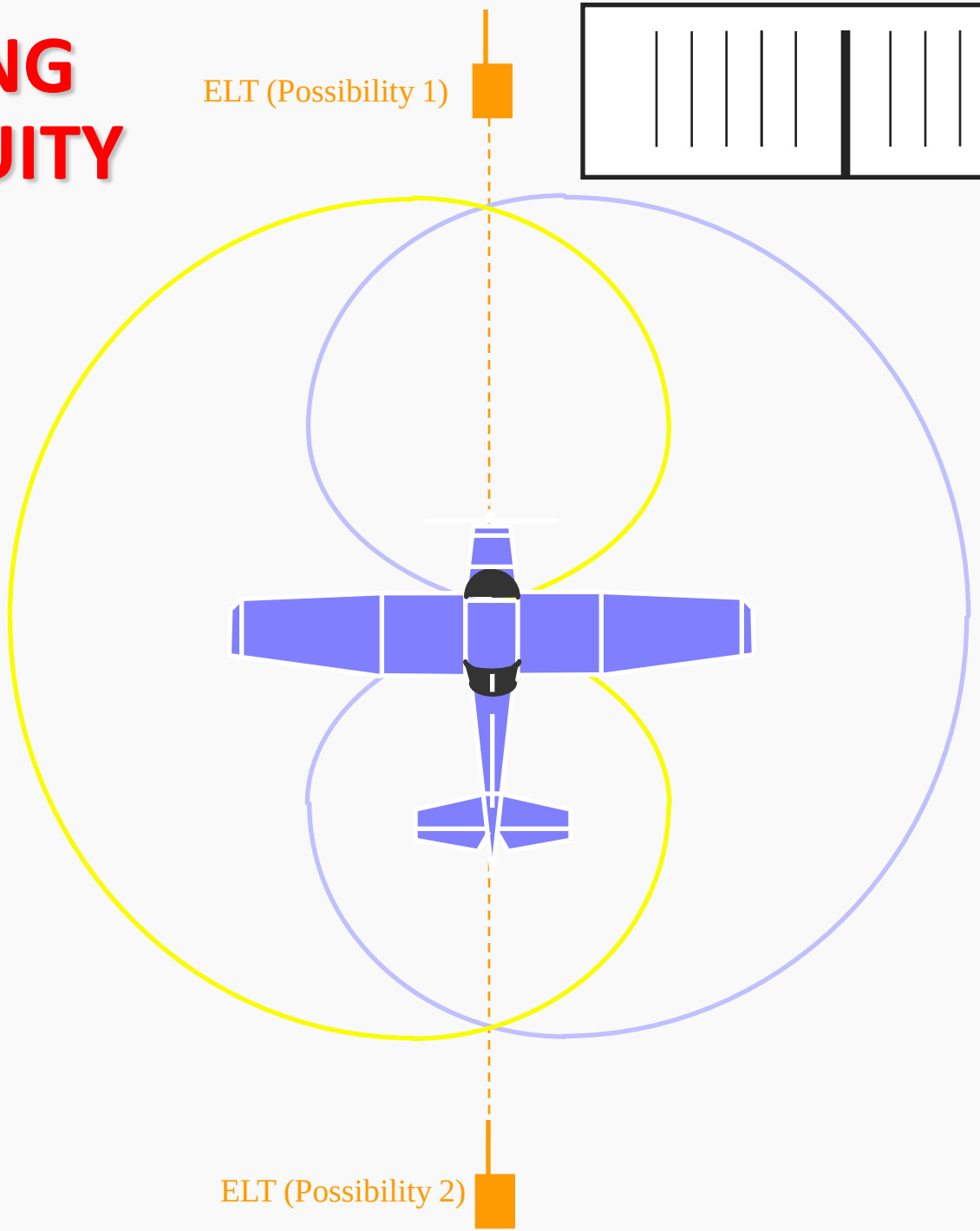


- Actual ELT position is unknown to user
- Make a small turn left or right
  - As a teaching reminder, “Use a TURN to TELL”
- Example:
  - TURN LEFT
  - If needle goes left
  - ELT is to your left (behind you)



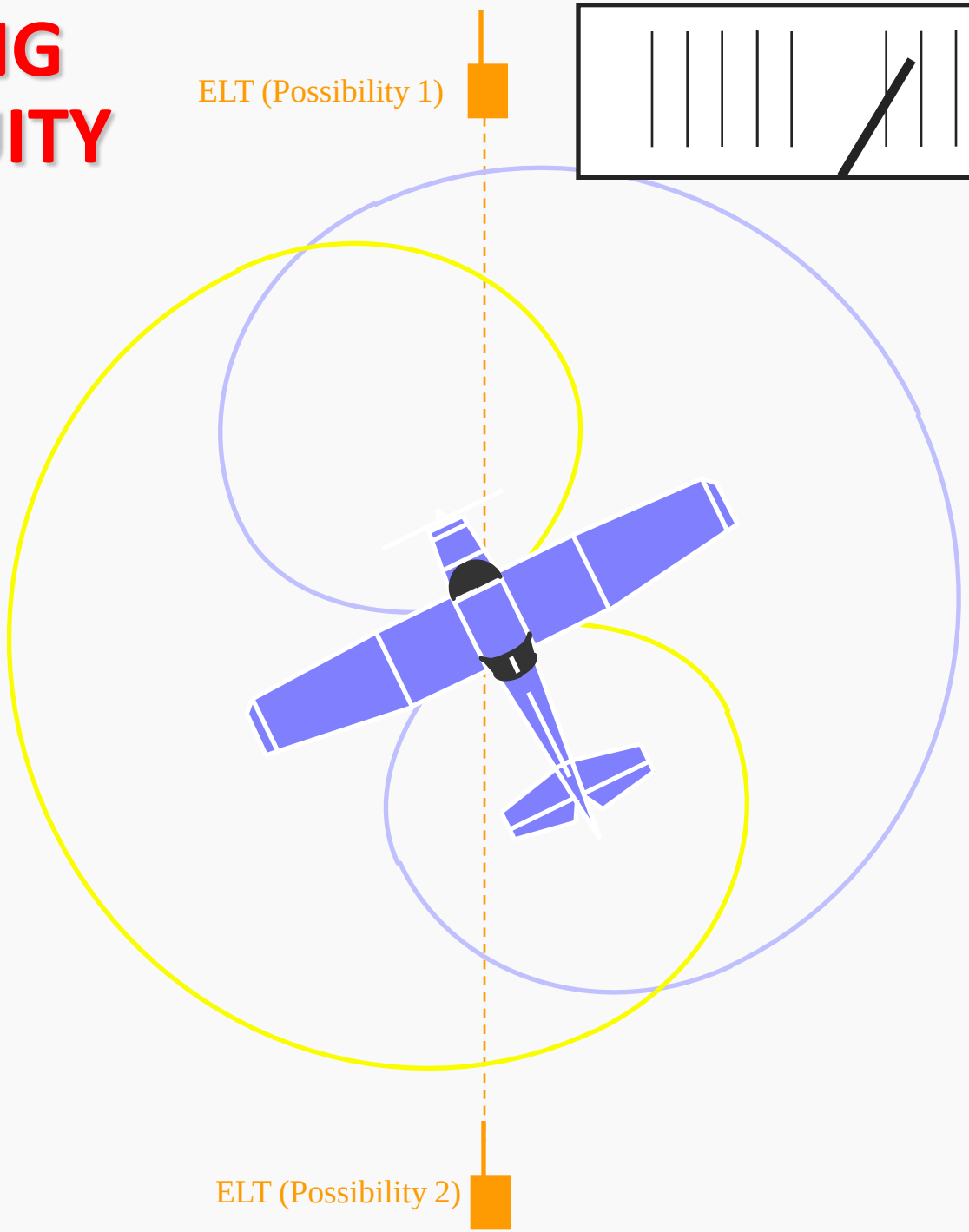
SOLVING AMBIGUITY

- If you turn Left and the needle moves Right
- The ELT is in Front of you!

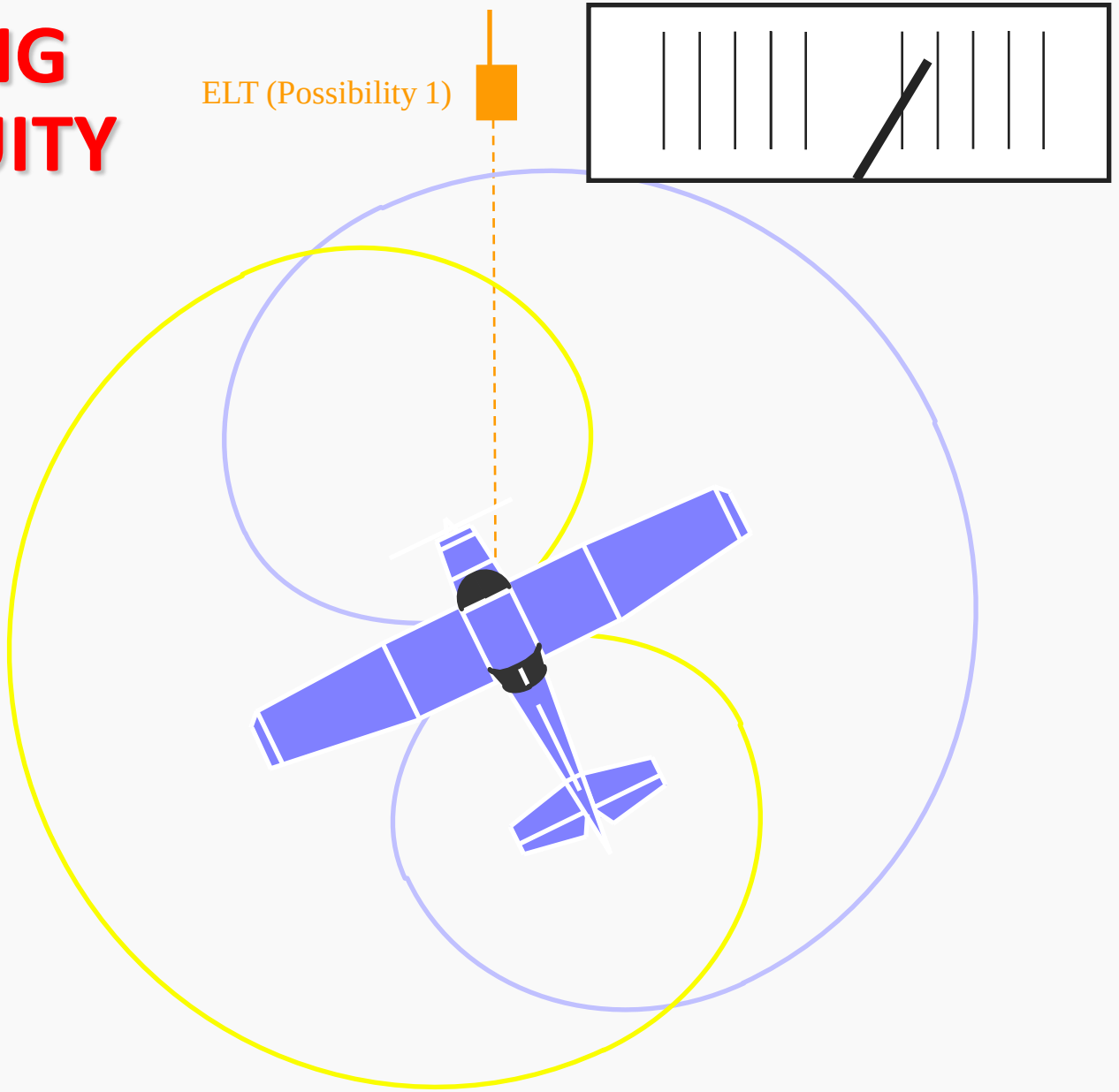


SOLVING AMBIGUITY

- If you turn Left and the needle moves Right
- The ELT is in Front of you!
- Example:
  - Turn left
  - Needle goes right

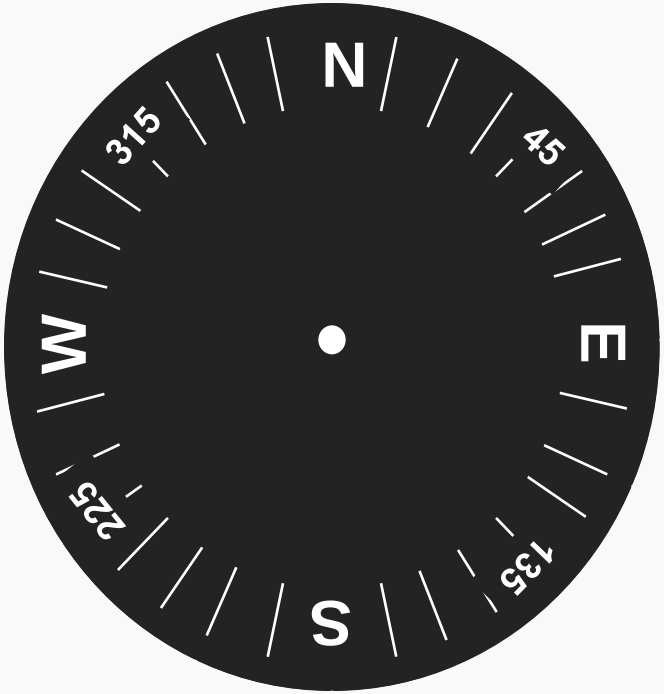


SOLVING AMBIGUITY



- **Solution:**
  - **If you turn Left and the needle moves Right**
  - **The ELT is in Front of you!**

Step 6: SHOOT



- Use your DG to determine a bearing to the target & follow it
- You may need to fly through a zone of signal dropout
- Be watchful for signs of signal passage
  - If you get signal passage, consider using the “pinpointing the target” techniques listed in this presentation
- Frequently repeat the full six steps to ensure you are heading in the right direction and that you didn’t inadvertently over fly the ELT

How A DF Unit Works: Summary

- Two Main Modes of Operation
  - RECeive
  - DF
- RECeive Mode is a Strength Meter
  - Left is low, right is high
- DF Mode Centers on Signal
  - Always points to the signal
  - Use a Turn to Tell when solving ambiguity
- Aircraft and ground units work the same way

Reflections

- Reflections of an ELT signal work just like a flashlight off of a mirror
- Any flat, hard, or wet object can cause signal reflections
  - Mountains, especially cliff faces
  - Hangars and other metal structures
  - Wet grass or snow
  - Large bodies of water or ice
- Power lines can also have a large effect on a low-powered signal such as an ELT

Beating Reflections

- Check your sensitivity at half-scale or lower
  - But ensure that its high enough to receive adequate signal
- Reflections will generally be weaker than the most direct path to the target
- Following reflections will generally take your closer to the target
- If sensitivity is set to minimum, try DFing on a different frequency
  - For example, if you are trying to locate an actual ELT on 121.5 MHz, try locating it on 121.6 or 121.775 MHz when you get close
- When all else fails, fly somewhere else to get a good DF bearing- or try that at the first sign of problems!

Carrier-Only Signals

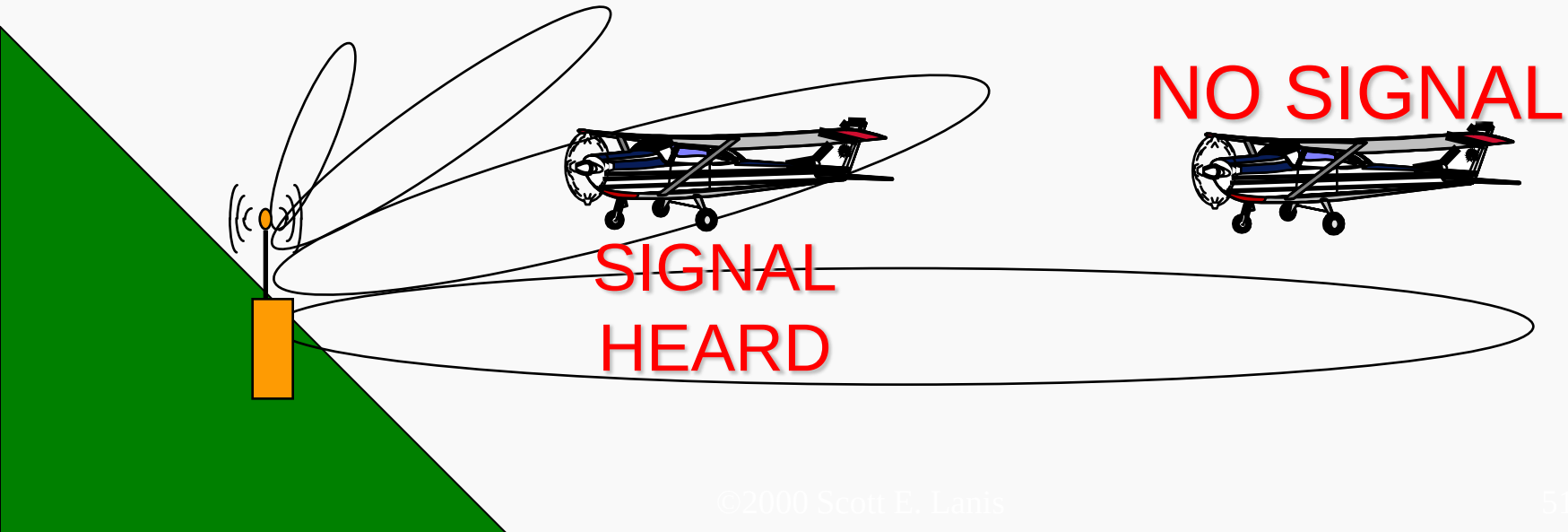
- You don't always need to hear the ELT or EPIRB to find it
  - A carrier-only signal may be broadcasting with no audible sweep
- This is especially true with low or old batteries, damaged ELTs, or spurious transmissions
- You can identify a carrier-only signal by DEFLECTION
- Good needle deflection generally indicates a signal that is strong enough to DF
- Compare your deflection to another frequency
  - If you are using 121.5 MHz, try it on 121.775 MHz
- If deflection is the same in both frequencies, you DON'T have a signal, just random noise
- If deflection is different, keep at it! You have the signal.
- If a signal is *only* received on 243 MHz, it *may* be a malfunctioning antenna (e.g., an FAA tower). If you DF to the location (particularly on or near an airport) and you keep ending up at an antenna, investigate. Find out who owns the antenna and its purpose. Inform the IC and let the controlling agency troubleshoot the problem.

Vertical Reflections & Signal Dropout

- The transmission pattern (similar to the reception pattern of the DF antennas, only for transmission) of an ELT is not a perfect circle or sphere
- It has lobes, or, stronger and weaker points
- This is accentuated when the ELT is transmitting from a location above the surrounding ground
- When you get a good DF heading and the signal fades or drops out completely you may just be outside of one of the signal lobes
- When you reacquire the signal, it should be stronger than when you lost it

Signal Dropout

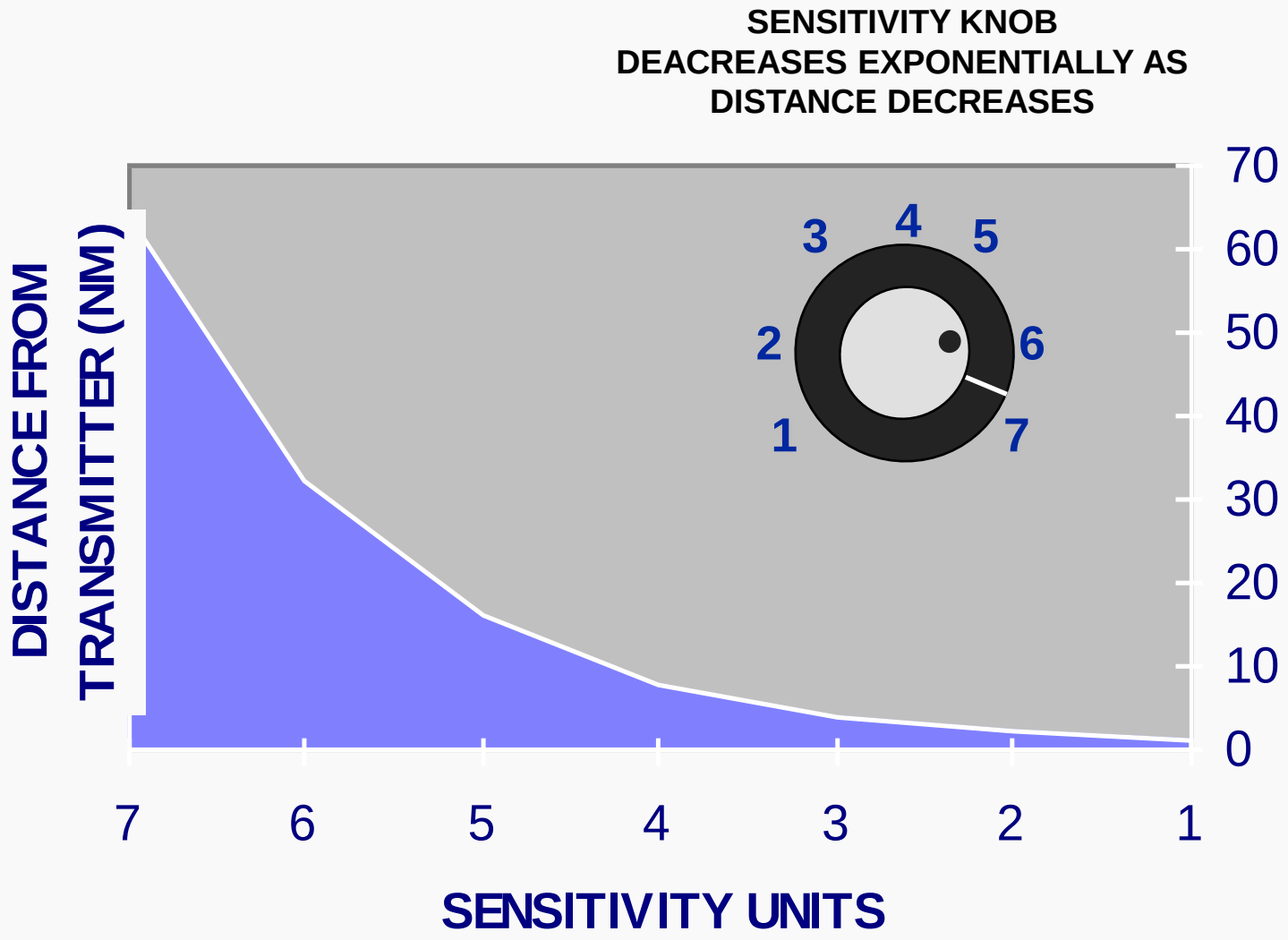
- If you encounter a signal dropout, continue to fly on your last good DF heading
- You should reacquire the signal in a few minutes
  - Actual time will depend upon your distance to the target
- If you are unable to reacquire, return to where you last heard the signal and re-DF



Signal Strength

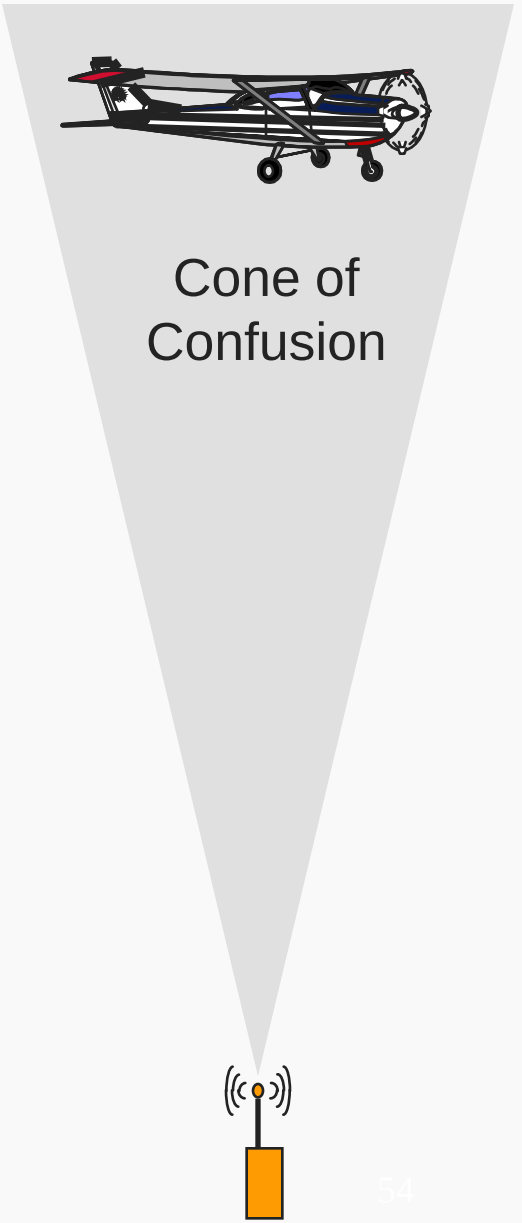
- The *rate of change* in signal strength increases as you get closer to the transmitter, and RECeive mode or the STRENGTH window measures signal strength
- This is due to Maxwell's inverse square law:
  - When you double the distance from an object, the energy it you receive from it is 1/4 of what you originally received, or the inverse square: $1/(2^2) = 1/4$
    - After Scottish Physicist James Clerk Maxwell, 1831-1879
- You will therefore need to turn down the sensitivity to keep the unit at half scale in the RECeive mode or STRENGTH window much more often as you get close to the source of the signal
  - This should let you know that you're getting close

Signal Strength Rate of Change



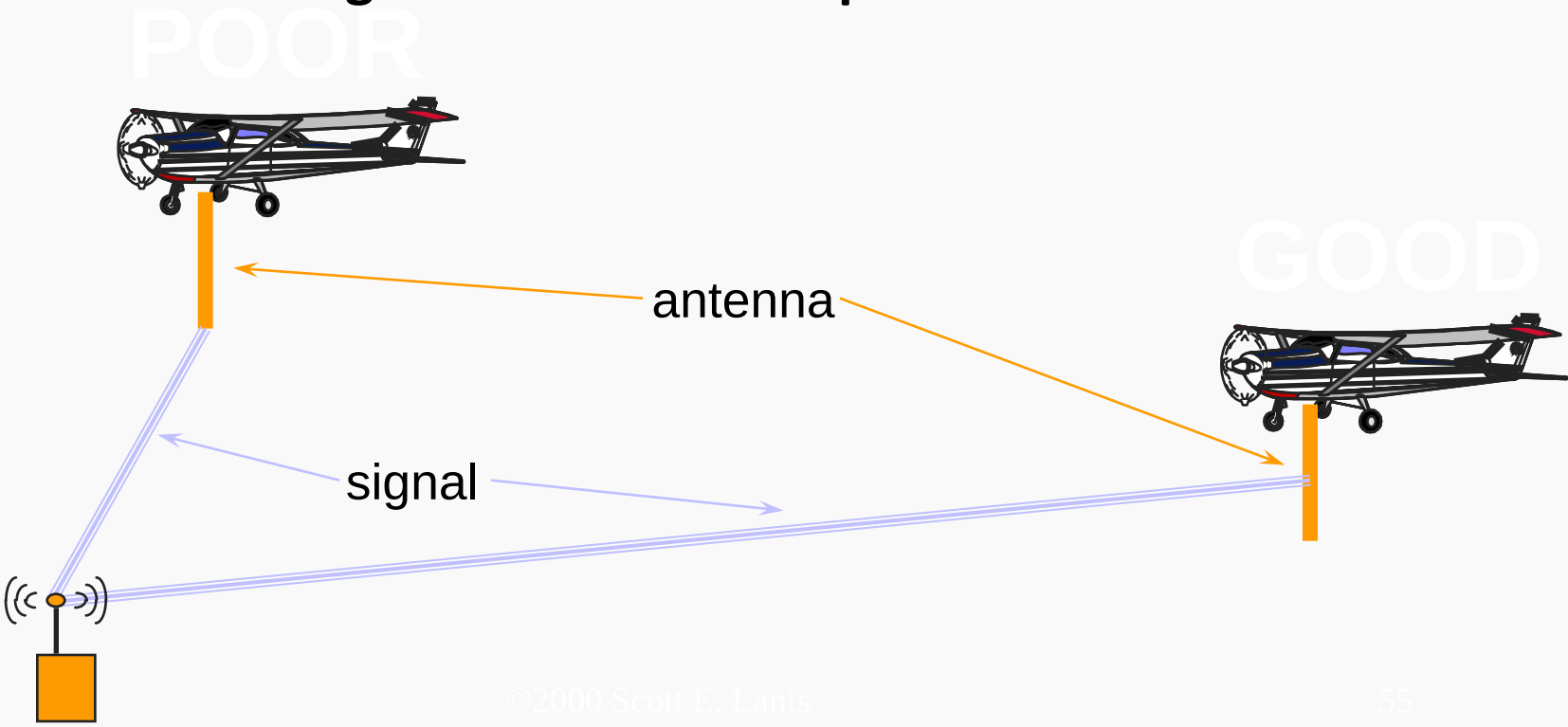
Cone of Confusion

- Antennas receive best when the pole is perpendicular to the signal
- When you approach the directly overhead position on an ELT, your DF will become unreliable
  - It may swing left and right
  - It may center regardless of your heading
- You should practice to see what this “station passage” reading looks like
  - It is similar to crossing a VOR



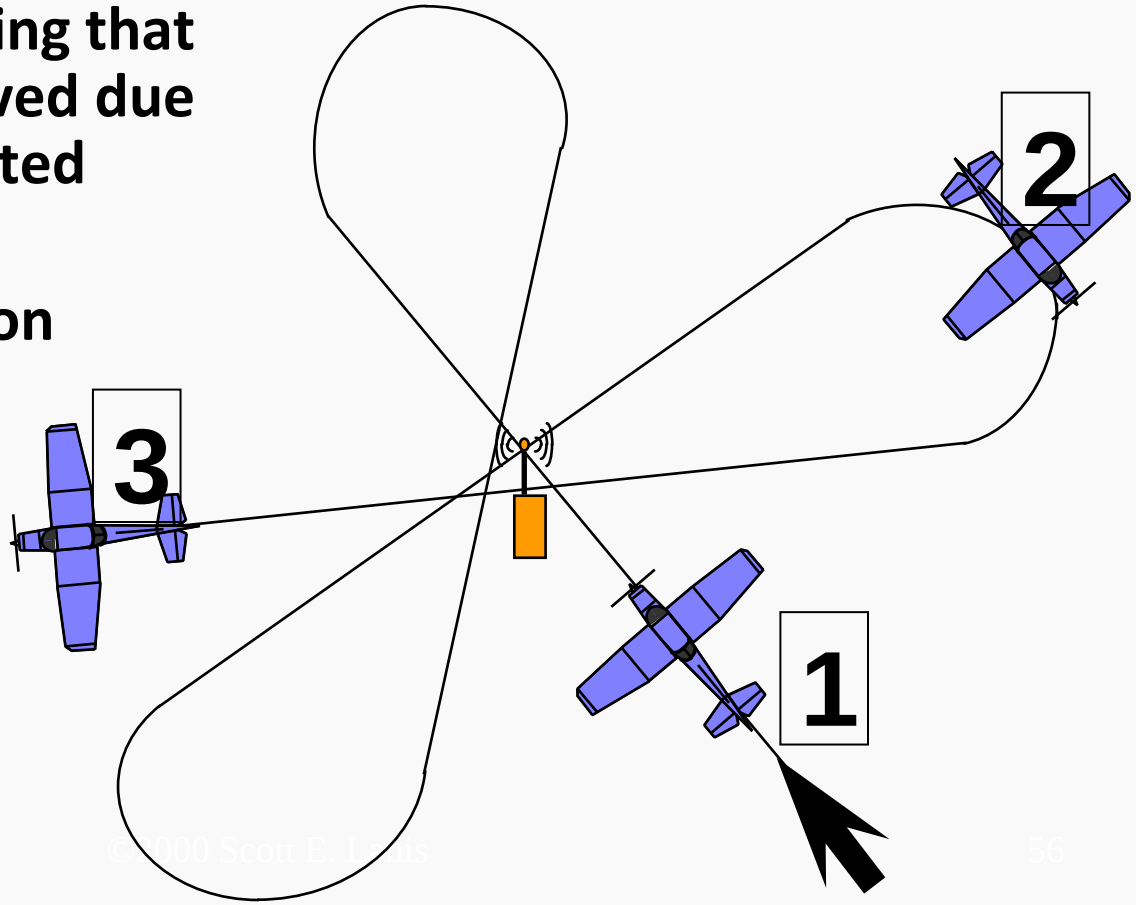
Reception in the “Cone of Silence”

- You may also get a significant drop in ELT signal since the antennas don’t receive well directly off of their tips
- Although called a cone of silence, you will probably only see & hear a large decrease in signal instead of complete silence



Pinpointing the ELT

- If you get a station passage indication, make an approximate 180 degree turn and DF back to the target
- Repeat this process using different approach angles each time, remembering that your path may be curved due to wind (like uncorrected NDB holding)
- The point where station passage is received several times should be the location of the target



Pinpointing the ELT

- **After you think you have the target located**
  - make a low pass over the suspected location and visually scan
  - if signal strength decreases significantly or drops out, climb back and try again
  - this is not the target: sometimes false targets will appear due to reflections or other interference
- **If you hear the ELT at low altitude, you probably have the right place**
  - a low pass down a runway might be a good idea if you suspect a particular airport